Gain enhancement design of Aperture Coupled MPA at1.5 GHz

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Abstract—*Micro strip patch antenna by default is low cost small in size easy to fabricate but have lower gain. In this research paper we have designed an antenna &aperture coupling is provided to increase the gain. The mathematical model is based on transmission line & design at 1.5 GHz is simulated & parametric study is made. The VSWR & directivity are within acceptable limits.*

Keywords—**aperture coupling, directivity,parametric, patch, vswr**

I. INTRODUCTION

The modern era is marked by rapid progress in the field of communication Micro strip Patch Antenna is commonly used in GPS systems, spacecraft etc. This type of antenna is small in size, low weight & economical to fabricate at industrial level. By default the MPA has low gain & small bandwidth. The inherent short comings can be removed using aperture coupling for exciting the antenna.

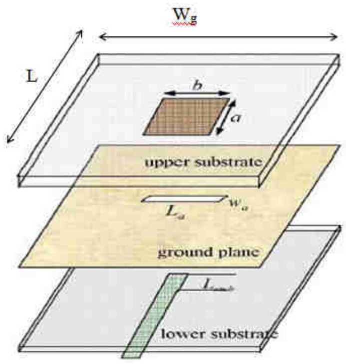

Fig.1(a): Isometric view of Antenna

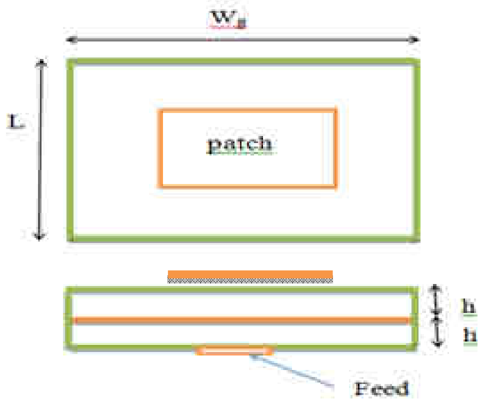

Fig.1(b): front view of Antenna

II. DESIGN CALCULATION & ANALYSIS AT 1.5 GHZ

The Aperture coupled antenna with rectangular patch consists of substrate with feed line at the bottom. Themiddle layer called as Ground plane is made of copper with a rectangular slot. Top substrate has a printed radiating patch of copper.

III. DESIGN CALCULATIONS

1. Operating frequency 1.5 Ghz

The dielectric constant lies in the range $2.2 \leq \mathcal{E}r \leq \mathbf{12}$ both the substrates G10 (lossy) substrate is used for simulation $\mathcal{E}_0 = 4.7$, h =1.6 mm.

Let us determine

W, L Operating Frequency 1.5 Ghz

Return loss <-10 db.

Substrate dielectricconstant = 4.7 , h = 1.6 mm

$$W = \frac{1}{2xfr}\sqrt{\mu o \mathcal{E}o}\frac{\sqrt{2}}{\mathcal{E}r+1} \quad (1)$$

= 59.23 mm

$$\mathcal{E}_{ref} = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2}\left[1+12\frac{h}{w}\right]-^{1/2}$$

=4.458

$$\frac{\Delta l}{h} = 0.412\frac{(\mathcal{E}_{ref}+0.3)\left(\frac{w}{h}+0.264\right)}{(\mathcal{E}_{ref}-0.258)\left(\frac{w}{h}+0.8\right)}$$

=4.6 mm(2)

$L = \frac{\lambda}{2} - 2\Delta L$ =38.19 mm

$W_g = 6\text{h} + W$ =68.83 mm

$L_a = 6\text{h} + L =$ 47.79 mm

2. Height of the substrate =1.6mm

$h \leq 0.3V_0/ 2\pi fr$ (3)

V_0= speed of light

3. Microstrip feed line design : Commonly 50 Ω impedance feed line used to feed the radiatingpatch & this 5mm by feed line width . To

optimize the coupling the feed must be placed normal tocentre of the slot.

4. Calculation of Aperture is controlled by slot dimensions. Length of aperture (Lap) & width of aperture is small about 1.55 mm is considered in our design.
5. Stub : Stub length is the length after the feed line used to time excessive reactance of the aperture.

IV. DESIGNPARAMETERS OF APERTURE COUPLED ANTENNA

Dielectric constant	4.7
Thickness of substrate	1.6mm
Length of the patch (Lp)	59.23 mm
Width of the patch (Wp)	38.19 mm
Width of the aperture(Wap)	1.55
Length of the aperture (Lap)	14
Width of the feedline (Wf)	5

V. SIMULATION USING CST

S –Parameter plot :-

An s-parameter plot show you the values of the s – parameters (vertical axis in –dB) plotted as curve against frequency range (horizontal axis) the antenna is acceptable for a desired frequency is below – 10dB.

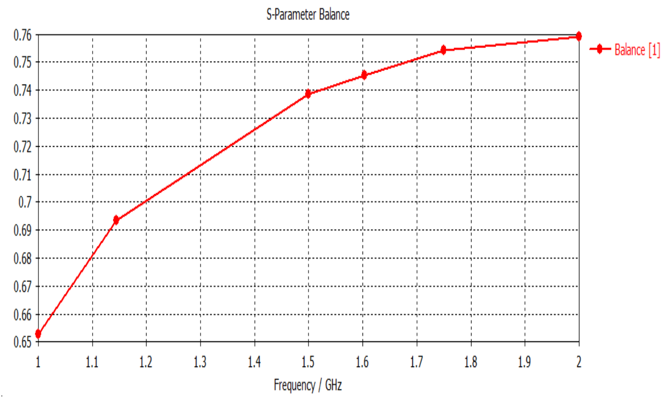

Fig.2: *S –Parameter Balance plot*

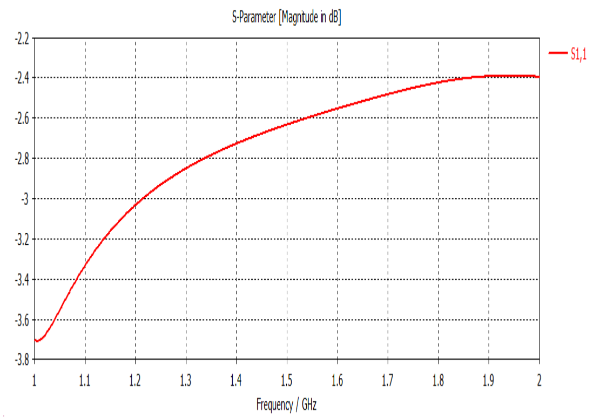

Fig.3:*S11 –Parameter plot*

Far Field Plot :-

This plot shows you the gain of an antenna for a given frequency in all its directions.

2D plot : a point on a sphere can be expresses as the radius & 2 angles they are defined as the angles this radius makes with 2 perpendicular planes. These 2 planes are either XY,XZ,or YZ plane & the angles the radius makes with these 2 planes are called theta & phi as shown below.

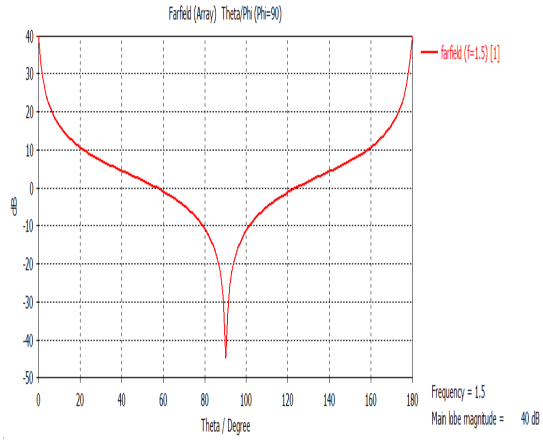

Fig.4:*Graph showing Far Field*

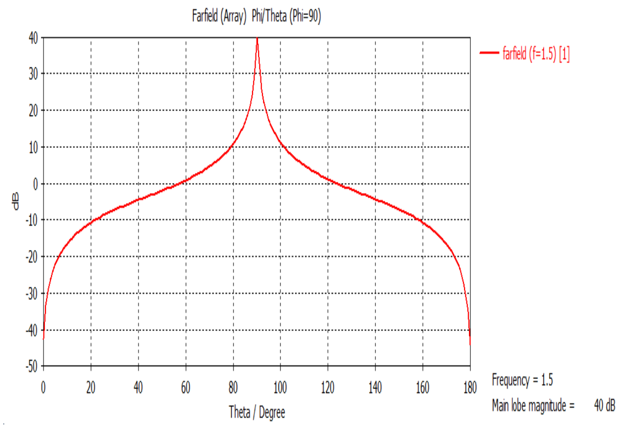

Fig.5:*Graph showing Far Field Array*

Aperture coupled MPA can have polarization ratio 10dB greater than the other MPA normal to the other antenna surface the co-pol a polarized radiation (at $\Theta = 0^0$&Ǿ $=0^0$)gain is 6db & gross polarization gain is -37.68db(Ǿ polarization radiation at $\Theta = 0^0$)

This yields polarization ratio of 43.29db

Parametric study:

After realizations of all performing parameter such as f_0, VSWR, bandwidth, polarization ratio etc. are recorded Material used are copper (pure) for feed line, patch& ground plane substrate is modeled as G10 (lossy) , Refractive index 4.7

Component is modeled using CST Microwave Studio modeling tool. Nominal antenna design is used as base

line for reference. One variable is adjusted at a time and rest of the parameters is fixed. The observations are as under.

Patch length

Increasing the patch length decreases the operating frequency and resistance. This increases the reactance.

VI. CONCLUSION

A linearly polarized aperture coupled antenna is designed & modeled in CST studio (computer simulation and testing software). The results are encouraging and practical observations confirm that manual calculations. Further, the parametric study of all the basic parameters, like line parameters, line dielectric material, patch dimensions, dielectric height, coupling slot dimensions are manipulated & practical observations are made & displayed graphically. It is compact and easy to fabricate and efficient to manufacture.

These results are used as the base line forparametric study of the antenna. The frequency where minimum |s11| value occurs is called operating frequency.

S_{11} parameter Maximum power transfer to the antenna occurs when $VSWR_{in}$ approaches unity.

The aperture coupled antenna is defined as the frequency range over $VSWR_{in}$ is less than 2. The antenna bandwidth is 20 MHz (.88% relative to f_0)

$VSRW_{in}$ = 2(threshold)

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